THE

VETERINARY JOURNAL

DECEMBER, 1939

Editorial

RETROSPECT—PROSPECT

As the year draws to its close, it is a wholesome thing to reflect upon the events of the preceding months and by so reviewing them to take stock of the progress that we have made for the advancement of our profession.

What can be said of 1939? What has been the fate of those resolutions and plans which were so hopefully made twelve months ago? It may be that the less said the better, for our lives have been so overshadowed and disorganised by the calamitousness of international affairs. The repercussions of the war have been felt by all. Practices have been seriously affected, our schools have suffered and research activities have been seriously curtailed. Now that the first shocks of war have been successfully negotiated, it behoves us to take stock as to how we can best uphold the traditions of our profession and keep alight the torch of our culture and science. It is essential that we give of our best to the State and to our profession. How can this be done? There should be no diminution in the activities of the many veterinary societies. These societies are the very basis of our professional and social intercourse. A survey of veterinary literature will amply substantiate the claim that the bulk of our present-day knowledge has emanated from the deliberations of past and present members of these societies. Times of stress often lead to the retirement of members, and we would urge all our readers to realise that now is the time when they should redouble their support to their local society and to the parent body, the N.V.M.A.

The exigency of war has made necessary the provision of a scheme for the protection of animals in the event of air raids. The common cause has drawn together representatives of the profession and also of the various animal societies, and N.A.R.P.A.C. has been the result. The chief executive officer is a veterinarian and the whole scheme has been planned with a harmony which few would have deemed possible a few months ago. Let us hope that this collaboration may persist when the needs of the present time have passed.

The R.A.V.C. earned great tribute in the World War, 1914-18, but owing

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to the policy of mechanisation there were many who thought that its days were numbered. What do we find? There are signs not only of resuscitation, but complete revival of its activities. At the outbreak of war it was simply a small but efficient cadre ready for any emergency, and now there is reason to believe that it will attain something of its pristine glory. It may make calls upon the profession which we can assure those in authority will be answered with alacrity.

On the home front food production and control are major issues. In this sphere the veterinary profession can render great aid. It is to be hoped that those in authority will recognise this fact and make more use of those who are, by virtue of their training, competent and willing to help with their services.

Food production and stock raising is not an insular question; we must make full use of the resources of our colonies and dominions. The colonial veterinary service should be rapidly augmented and, above all, there should be no delay in the appointment of a veterinary officer at the Colonial Office. The need of such an appointment is manifest, for he could co-ordinate and collate the activities of the officers in their various spheres of work.

In spite of the war and its many restrictions, it is our hope during the coming year to keep this journal up to standard in quality, material and interest. As Christmas is close at hand, may we take this opportunity of greeting all our readers with best wishes for the season and during the new year.

ROYAL (DICK) VETERINARY COLLEGE EXTENSION FUND

THE Principal of the Royal (Dick) Veterinary College has had a stroke of luck! In order to assist in raising the comparatively small sum now needed to complete the main extension of the College as proposed in the original £40,000 scheme, Lord Forteviot, who has already subscribed very generously to the fund, has now offered to subscribe a further £500 when a corresponding amount has been received from the public.

Furthermore, when the £1,000 thus raised has been paid into the fund, a corresponding amount will be contributed by Government. Contributions to the fund will therefore be more than doubly effective, and it is hoped that those who can afford to do so will take this opportunity to help to bring this extra accommodation, which is very sorely needed, into use before October, 1940.

"Bis dat qui cito dat." The times are indeed difficult but we hope that the small sum required to secure Lord Forteviot's gift will be soon collected.

General Articles

INVESTIGATIONS ON THE SEMEN OF FERTILE AND STERILE BULLS

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In 1935 when experiments on artificial insemination of cattle in Kenya were started, it was found that there was great variation in the quality of the sperm produced by different bulls. More extensive investigations were accordingly undertaken and a large number of sperm tests and clinical examinations of the genital organs of bulls were carried out. It is the object of this paper to present an account of these investigations with particular reference to a characteristic form of sterility due to epididymitis, which has been found in many bulls in Kenya.

There has been a tendency to overlook the bull as a possible cause of sterility and in the early part of the century sterility was explained by genital disease in the cow rather than in the bull. Certain workers, however, believed that the bull was an important factor in sterility, but it was not until W. L. Williams in 1921 investigated sexual diseases in animals and established an improved method for sperm examination that the subject was put on a sound basis. Further investigations were made by Williams, W. W. (1920, 1922), Williams, W. L. (1932), Gilman (1922, 1923), Gilman and Hopper (1925), Williams, W. W., and Savage (1925, 1927), Fincher (1928), Conklin (1929, 1930), Donham, Simms and Shaw (1931), and Lagerlof (1934, 1935, 1936 a and b, 1937), etc. Lagerlof in 1934 published a most comprehensive account on morphological changes in spermatozoa and their relation to morphological changes in the testes. Since this publication contains an extensive bibliography the literature is not discussed in any detail in this paper.

Fertility in the Bull

It is well known that different bulls vary considerably in their fertilising capabilities. The average percentage of fertile services, for example, in a number of American herds has been shown to vary from 32.7 to 62.7 with an average of 52.7 (W. W. Williams, 1922; W. L. Williams, 1922; Moseley, Stuart and Graves, 1932; Fitch, Boyd and Delez, 1929; Conklin, 1930; Eckles, 1932; Miller and Graves, 1932; Knoop and Hayden, 1934). Some of this variation in the number of services required for conception was no doubt

attributable to the cow, but a considerable part of it, at least, was due to the bull. Miller and Graves (1932), for example, noted considerable differences in the breeding efficiency of different bulls when mated to fertile cows.

The fertility of bulls in Kenya, mainly pure-bred bulls of different breeds, estimated from cows with good breeding records, has been found to vary from 10.2 to 62.8 per cent. in different grade herds, with an average of 27.6 per cent., and in two herds of Zebu cattle the average fertility of the bulls was 71.4 per cent. and 83.3 per cent. respectively (author, unpublished data). The number of services required for conception in the grade herds thus varied from 1.5 to 9.8 with an average of 3.6, and in the Zebu herds an average of 1.3 services was required for conception. Individual bulls showed great variation from complete sterility to a maximum of 77.4 per cent. fertility in pure-bred bulls and to 100 per cent. fertility in Zebu bulls. The fertility of a group of 51 bulls, estimated from services with normal healthy, regularly breeding cows, is shown in the following table:

TABLE 1

% of Fertile Services	*No. of Bulls*	*% of Bulls*
60 and over	7	13.1
50 „ „	11	21.5
40 „ „	20	39.2
40 and under	31	60.7
10 „ „	8	15.1

It has been found from artificial insemination experiments in Kenya, using sperm from highly fertile bulls in normal, regularly breeding cows, that, at the best, 1.5 to 2.0 inseminations are required per conception, and in Russia after a single insemination it has been found that 30-40 per cent. of cows return to the bull (Andreev, 1937). From these experiments and from examination of the breeding records, it therefore seems that when highly fertile bulls are used with normal, regularly breeding cows about 1.5 to 2.0 services are required per conception (i.e., when a single service or insemination is allowed during one heat period), and it appears probable that this number of services per conception should be regarded as approximately the normal standard and, moreover, that any great increase in the number of services required for conception should be considered abnormal. It is clear from the records of the above bulls that a considerable percentage exhibited an abnormally low fertility.

Frequency of Sterility in Bulls

There is comparatively little information on the incidence of sterility in the bull, though the view is now more commonly held that the bull can play a not inconsiderable part in bovine sterility. W. L. Williams (1921) stated that "speaking in percentages the bull is probably as great an offender as the

cow. In other words, probably as great a proportion of bulls as of cows go to slaughter on account of sterility or low fertility." Williams, W. W., and Savage (1925) found that 68 (34.4 per cent.) out of 198 bulls were unsatisfactory for fertility. From an examination of the 1928-1932 records of the Swedish Bull Associations, Lagerlof found that 2,313 bulls were culled for the following reasons: fear of inbreeding, 38.7 per cent.; sterility, 23.6 per cent.; disease other than sterility, 13.7 per cent.; heaviness or viciousness, 11.2 per cent., and causes unknown, 12.8 per cent. The records of the Scandinavian Cattle Insurance Society showed that of bulls insured at the age of 1½ years, 8.5 per cent. were discarded as sterile before they reached the age of two years. Richter (1932) found that only 14 bulls (9.6 per cent.) out of a total of 2,185 bulls in Saxony were sterile, but, as Lagerlof stated, it is probable that a number of sterile bulls were overlooked. Smith and Robinson (1931) found that the average service time of bulls was only 1.85 years and believed that bulls were often sterile. Rasmussen (1934) said that sterility is common in communal bulls in Denmark.

A form of sterility in bulls associated with chronic changes in the epididymis and testis was first seen in Kenya about 1928 and since then it has been recognised on many European-owned farms throughout the country (Daubney, Hudson and Anderson, 1938). The disease occurs in pure-bred bulls of different breeds, in high- and low-grade bulls, and the Masai apparently know the condition and refer to it by the same name as that used for gonorrhœa in man. The available evidence suggests that the disease is transmitted by coitus and that it has spread from farm to farm by the introduction of bulls or female stock. It is highly probable that a considerable amount of bovine sterility experienced in Kenya in recent years has been due to this condition.

Clinical Investigations

History.—An examination of the service records can usually show whether the bull or the cows are at fault—as Lagerlof states, if the fault lies with the bull the majority or all of the cows served by him will have returned to the bull and will have held subsequently to service by other bulls. If the fault lies in the cow usually a number will have conceived while others will have returned to the bull; also clinical examination can usually reveal abnormalities in the genital organs of the cow. The grade of fertility of a bull can be estimated from his services with fertile cows. The owner usually knows fairly well how his cows are breeding from the calvings, but it is often otherwise with bulls, especially if they serve cows normally. Lagerlof has pointed out that the owner does not usually recognise degres of fertility in the bull and if a bull is capable of impregnating a few cows it is usually considered to be of normal fertility, though his fertilising capabilities may actually be very low

It is important that the investigator should examine the service records himself, for a statement by the owner that a bull is a good calf-getter is often inaccurate. It can be determined from the service records when a bull began to show reduced fertility or sterility.

The form of sterility in Kenya already referred to as being associated with chronic changes in the epididymis and testis, commonly assumed the characters of a contagious disease when it made its first appearance in a clean herd and resulted in what could conveniently be termed an "outbreak" of sterility. As a result cows and heifers returned constantly to the bull. Commonly, the condition was reported when no calves had been born for several weeks and when none of the cows were apparently in calf. An outbreak would run its course in a herd for a period of 1-2 years, during which time no calves might be born. The introduction of new bulls resulted in the majority of the cows getting in calf again, but eventually these bulls in turn often became sterile and further new bulls became necessary. When the condition finally cleared up a varying percentage of female stock remained permanently sterile (Kenya Department of Agriculture Annual Report, 1933; Conference on Co-ordination of Veterinary Research, 1934; Daubney, Hudson and Anderson, 1938).

Clinical Examination of the Genital Organs of the Bull

Lagerlof (1934) has found that in most cases of impaired fertility it is impossible to determine abnormalities in the genital organs by inspection and palpation. In hypoplasia and fibrosis of the testis, the testis is sometimes smaller and firmer, but in most of these cases and also in cases of degenerative changes in the testes it is usually impossible to form an impression of the functional capacity of the testis. In orchitis and periorchitis due to *B. abortus* there are, as a rule, definite symptoms with marked swelling and pain in the affected half of the scrotum, and in most cases of orchitis due to this organism a marked thickening of the deferent duct on the same side as the affected testicle can be found.

According to Williams, W. L. (1921) and Gilman (1923) infection of the epididymis is usually localised in the tail. Sterile bulls in Kenya show very constant typical lesions. This occurs mainly in the epididymis and particularly in the tail of the epididymis, which becomes enlarged and indurated. The testis may also be affected. Frequently the enlargement can be seen when standing behind the bull and it can always be detected during life by palpation. Instead of being loose in the scrotum the testicles are often firmly adherent to the inner lining of the sac (Daubney, Hudson and Anderson, 1938).

Infectious processes of the seminal vesicles are thought to be very common (Williams, W. L., 1921; Gilman, 1923; Williams and Savage, 1927), but Lagerlof (1927) found marked changes in the seminal vesicles in only seven

bulls. Lagerlof remarks that it is usually quite difficult to discover by palpation whether this organ is normal (and the author is also of this opinion); with increasing age they become thicker and firmer and a certain sensitiveness to touch appears physiological. Williams, W. L., and Gilman state that the prostate and bulbo-urethral glands are seldom affected.

Ability and Desire to Serve

Lagerlof (1934), from the records of the Scandinavian Cattle Insurance Society, noted that of 161 bulls slaughtered as sterile in one year, 8.8 per cent. were removed for poor sex instinct and 54 per cent. for inability to serve. This author remarks that in certain cases it is difficult to differentiate between faulty sex impulse and inability to serve. Williams, W. L. (1921) and Gilman (1923) maintain that an acute infection of the seminal vesicles or testes causes pain on service and that the bull is either unwilling or unable to serve, but Lagerlof has not found this to be the case. It has been noted by Lagerlof that willingness and ability to serve are not indications of fertilising capacity.

Sperm Investigations

At one time sperm investigations dealt almost exclusively with number and motility of spermatozoa and motility was identified with fertilising capacity. The examination was regarded as a simple process—to demonstrate if living spermatozoa were present or absent. Some workers, however, believed that the presence of active sperm was no proof of fertility. Williams, W. W., and Williams, W. W., and Savage, as a result of their investigations of fertile and sterile bulls from 1920-1927, concluded that the degree of fertility could be determined from the morphology of the spermatozoa, and Moench (1931) came to similar conclusions in man. The investigations of Lagerlof in the bull have confirmed the view that morphology of spermatozoa is of importance for estimating fertility. Voloskow (1935) and Milovanov (1936) recognised the existence of pathological types and Milovanov believes that the number of pathological spermatozoa must be considered, in conjunction with other indices, in estimating fertility in male animals.

Methods for Collecting Bull Sperm

The artificial vagina provides the most satisfactory method for collecting bull sperm. This method is used extensively in Russia, by Walton in England (1936) and in Kenya (Anderson, 1937; Anderson and Daubney, 1938). Its main advantage is that the whole of the ejaculum is collected in a pure form and the sperm can be submitted to a complete examination. Other methods are less satisfactory (see Miller, 1937). Lagerlof collected the sperm from the vagina of the cow after service, the vaginal secretions having been previously removed as completely as possible. While this method is sufficient for collecting sperm for a morphological examination, it is doubtful if it is adequate

for a complete examination since the whole of the ejaculum may not be removed from the vagina after service and it is probably contaminated to a greater or lesser extent by vaginal secretions. The " drop " method used by Lagerlof, which consists in collecting sperm dropping from the penis of the bull after he dismounts from the cow, is not, as Lagerlof pointed out, wholly satisfactory because (1) no sperm may be obtained, (2) the amount of the ejaculum cannot be measured, and (3) it may not be of the same character as the main ejaculum. The method of obtaining sperm by massage of the seminal vesicles (Case, 1925; Fincher, 1928) was investigated by Miller and Evans (1934) who concluded that massaging the accessory gentital organs is a practical way of obtaining semen for physiological studies. These authors state : " For artificial breeding purposes it is desirable to massage the ampullæ, for from this organ will be obtained the greatest volume of semen containing active spermatozoa." The main advantage of this method is that sperm may be obtained from bulls which are either unwilling or unable to serve in the normal way. In the author's experience some bulls appear to yield sperm more easily than others by this method.

Microscopic Examination of Sperm

Volume.—The volume of sperm collected from the vagina of the cow has been found to be 6-8 ml. (Williams, W. L., 1921), 5-20 ml. (Wester, 1921) and 5-10 ml. (Gilman, 1921). The larger volumes found by these workers was probably due to the presence of secretions in the vagina of the cow. Kusnetzowa *et al.* 1932), using the artificial vagina, found that the average volume was 4.7 ml. and the range 3-6 ml. Lagerlof found that after removal of the secretions from the vagina of the cow the volume was from 1-7 ml. and usually from 2-5 ml., and he believed that the larger the bull the larger the ejaculum. Lagerlof noted (1) that the volume of sperm can vary in the same bull, e.g., on the first jump there is either no ejaculation or a small amount is given, while at the second or third jumps, carried out some minutes later, a much larger amount is given. In a bull with impaired or destroyed fertility the amount of sperm is usually normal.

2. *Physical Properties of Bull Sperm.*—Normally bull sperm is of an opaque, white or yellowish-white colour with a milky or milky-creamy consistence. The higher the concentration of spermatozoa, the whiter and thicker is the sperm, and when the spermatozoa are completely absent the ejaculum is usually a thin watery fluid. Sometimes, however, bull sperm is turbid and opaque though no spermatozoa are present. The colour may be affected by bleeding from the vagina of the cow from which the sperm is collected and sometimes from the penis of the bull. Lagerlof has noted that in some bulls large yellow floccules appear in a yellowish fluid and in some of these bulls a purulent infection of the seminal vesicles is found.

3. *Density of Sperm.*—Lagerlof (1934) found that (1) in bulls with good

fertility the count varied between 300,000 and nearly two million per c.mm., with an average of 800,000 per c.mm.; (2) in bulls with hypoplasia of the testes spermatozoa were absent or present in very small numbers, usually 50,000-150,000 per c.mm.; (3) with degenerative changes in the testes the number of spermatozoa was almost normal when the changes were slight, and when the changes were marked the number was much reduced or spermatozoa were absent; and (4) with infectious changes or fibrosis of the testes spermatozoa, as a rule, were absent or present in very small numbers.

There is great individual variation in sperm production in the bull (Lagerlof, 1934), in man (Moench and Holt, 1929), in the stallion (Lewis, 1911); Polowzow, 1929), and in the rabbit (Macirone and Walton, 1938). According to Lagerlof the bull can store such large quantities of spermatozoa in the ampullæ and epididymis that he can perform repeated services in the course of a few minutes without decrease in sperm production, and certain bulls can perform with good results for a long time one to two services per day without suffering harm (Kronacher, 1927). Lagerlof remarked that different bulls possess very different sexual possibilities and that the sexual exertion which does not affect some bulls appears to be able to harm others in a relatively short time. Macirone and Walton (1938) have investigated the fecundity of male rabbits by "dummy matings." They showed that there is a tendency for the number of spermatozoa to increase with the volume of the ejaculate. Seasonal variation in sperm production in the rabbit was not marked, but there was a tendency for the numbers to be highest in the early part of the year and lowest in August and September when the animal is moulting. In successive matings the number of spermatozoa diminish rapidly, but as the density is not much affected the diminution is due to reduction in the volume of the ejaculate.

It has been shown that sperm counts may prove valuable in the diagnosis of male fertility (Walton and Fair, 1928; Williams, W. W., and Savage, 1925; MacKenzie and Berliner, 1937). Walton (1927) considered that potential fertility or the probability of fertilisation was a direct function of the number and viability of the spermatozoa. Lloyd-Jones and Hays (1918) found that in the rabbit a big number of copulations in a short time decreased the volume of the ejaculum, the number of spermatozoa and the motility and that fertility decreased in the last ejaculations. Macomber and Sanders (1929) believe that in man it is the concentration of spermatozoa per ml. rather than the total number which is of importance for fertility, and Moench and Holt (1929) state that moderate oligozoospermia is compatible with perfectly normal fertility but the greater the number of spermatozoa the greater the chances of conception. Hutt (1929) believes that fertility in the cock is dependent on the physiological efficiency of the spermatozoa rather than upon quantitative production, and Lagerlof agrees with this view. Lagerlof believes that sperm can be affected functionally before they show deformity,

and that it is not always the small number of spermatozoa that hinders conception but in most cases deficient fertilising power of the formed spermatozoa. Macirone and Walton (1929) consider that variation in the density of spermatozoa may be a feature of importance in considering the potential fertility in different animals. They state: "Although in general the probability of fertilisation will be greater the larger the number of spermatozoa ejaculated, if this is at the same time accompanied by a relatively greater dilution, the spermatozoa may be handicapped, since experience with semen in vitro indicates a better survival in more dense suspensions."

4. *Motility of Sperm.*—While it is essential that spermatozoa be actively motile in order that they can pass along the female genital tract to effect fertilisation, many workers considered that motility is not a proof of fertility (Cary, 1916; Reynolds, 1916; Stieve, 1929; etc.). Williams and Savage in their investigations of bulls showed that no great weight could be placed on motility of spermatozoa. Lagerlof found that in sterile bulls and in bulls of reduced fertility the motility of the sperm was variable. In one bull with hypoplasia of the testes and in bulls with degenerative changes in the testes of a more or less slight degree, the motility of the sperm was usually good to very good. With more marked changes, however, the motility of the sperm was lessened or absent. In connection with estimations of motility, however, it must be remembered that various external conditions, such as low temperature, a too lengthy interval between collection of sperm and examination, drying of sperm on slide, possible harmful effects of vaginal secretions, etc., may cause loss of activity.

Sack and Amerbach (1930) believed that spermatozoa possess two independent centres, one motor in the middle piece and the other germinal in the head, and that a moving spermatozoon can fail in fertility. Milovanov (1936) stated that it is possible to imagine a state in which a spermatozoon whose head is incapable of fertilisation will exhibit active progressive movement, but on the other hand, absence of movement of the tail necessarily leads to loss of fertilising ability of the spermatozoon as a whole, though the head is capable of fertilisation. Thus good motility does not guarantee that the bull is fertile. Absence of motility or lowered motility, however, indicates reduced fertility or sterility.

Donham, Simms and Shaw (1931) found a definite correlation between the percentage of calving and motility of the sperm, and they stated that semen which contains less than 90 per cent. of active spermatozoa should be regarded as abnormal, since it does not ensure satisfactory fertilisation. In the stallion it has been found that a large number of active spermatozoa in the ejaculate corresponded to high fertility (Walton and Fair, 1928).

5. *Abnormal or Pathological Types of Spermatozoa.*—A somewhat different classification of abnormal or pathological types of spermatozoa is adopted by different workers. Milovanov (1936) stated that the divergence

in the classifications is explained not only by differences in the actual material but also by lack of sufficient knowledge of the subject. The significance of different pathological changes is not clear. Milovanov (1936) does not agree with Voloskow (1935) that the appearance of pathological types depends mainly on the sexual condition of the bull and the thermo-regulatory function of the scrotum. As Lagerlof has shown, the number of pathological spermatozoa is much increased in cases of testicular hypoplasia and of degenerative testicular atrophy. Milovanov distinguished two basic types of pathological changes in spermatozoa: (1) primary changes occurring during spermatogenesis which indicate the existence of pathological processes in the germinal tissue. These include giant and dwarf forms as well as all spermatozoa with changes in the head; and (2) secondary changes due to prolonged retention of the spermatozoa in the genital glands of the male, owing to infrequent matings or to abnormal composition of the accessory secretions. These include fracture of the neck, acephaly and twisting and looping of the tail. The significance of other types of deformity, e.g., split and filiform tail, is not clear. The significance of the two types of abnormal spermatozoa for the estimation of fertility is very different. The former type indicate a serious disturbance of spermatogenesis, while the presence of a large number of spermatozoa with fractured necks indicates incorrect husbandry.

The maximum number of pathological spermatozoa permissible for good fertility is comparatively low. In the bull Williams and Savage (1927) showed that fertility was diminished when abnormal spermatozoa exceeded 17 per cent. In 50 bulls of good fertility Lagerlof (1934) found that the count of abnormal spermatozoa lay between 2.4 per cent. and 17.2 per cent., with the average of 10.7 per cent. He believed that when the count exceeds 18 to 19 per cent. there is probably a disturbance in spermatogenesis which can be so serious that impairment of fertility is possible. About 42 per cent. of pathological spermatozoa were found in cases of hypoplastic testes and 30 and 37 per cent. in cases of degenerative changes in the testes.

6. *Immature Spermatozoa.*—Protoplasmic drops are usually on the neck of spermatozoa removed from the head of the epididymis, but on spermatozoa removed from the tail of the epididymis they are usually found at the end of the middle-piece. Lagerlof regarded as immature only those spermatozoa with drops on the neck. Attempts have been made to determine the degree of utilisation of a sire from the number of such spermatozoa in the ejaculate (Redenz, 1924) but it has been found that a large number of matings in a short time does not cause an increase in the number of immature spermatozoa (Milovanov, 1936; Lagerlof, 1934).

Lagerlof found that immature spermatozoa are absent or occur in very small numbers—2.3 per cent. in bulls with good fertility. In bulls with (1) hypoplastic testes the average number was 28 per cent. and (2) in cases of degenerative changes in the testes the number varied greatly. In cases of

experimentally induced degenerative changes in the testes they occurred during degeneration and regeneration. His investigations showed that a large number of immature spermatozoa is usually a sign of disturbance in spermatogenesis. If, in a young bull, is found a high percentage of immature spermatozoa together with a small volume of ejaculum and a large number of pathological spermatozoa it can be assumed that the testes are undeveloped. If immature spermatozoa are found in large numbers in older bulls it can be suspected that there is a degenerative process in the seminal epithelium; a renewed sperm examination after one month can often show if it is a regenerative or a degenerative change. Lagerlof further stated that the occurrence of a great number of spermatozoa with drops at the end of the middle piece appears to be connected with a great many services or masturbation; this is of no great significance in the case of a bull in service but in bulls which are not serving and for which there is no suspicion of masturbation this may signify a disturbance in spermatogenesis.

7. Biometrical Examination of Sperm Heads.—Savage, Williams and Fowler (1927) investigated the relationship between head length of spermatozoa and fertility. They found that in bulls of good fertility the head length showed normal or almost normal distribution and they maintained that the coefficient of variation of head length is the best proof of fertility. These workers also noted a similar relationship in the stallion (1930). Williams, Savage and Fowler considered that in normal bulls the coefficient of variation should not exceed 4. Lagerlof considered bulls with coefficient of 4 and under as probably of good fertility and bulls with values of 4.4 and over as of reduced fertility; the values from 4-4.4 being considered inconclusive. Lagerlof found that the coefficient of variation in (a) 30 fertile bulls was 3.7, (b) in 15 bulls of doubtful fertility it was 4.8 and (c) in 30 sterile or almost sterile bulls it was 6.2.

General.—Milovanov stated that the method of estimating fertility from evaluation of sperm by any one index, such as motility, or density of sperm judged by naked eye, is inadequate and may lead to grave errors. Methods tor testing the fertility of sires should accordingly be based on all the available indices and if, in repeated investigations, the indices of the sperm are found to be abnormal, there are reasons for believing that the fertility of the sires is either greatly reduced or altogether absent. The following particulars of normal sperm indices is taken from Milovanov, compiled from data of Milovanov and other workers :—

Volume of ejaculate, 2-5 ml.
Concentration of spermatozoa per 1 ml. (millions), 0.3-1.2.
Activity on a 10 point scale, 0.8-1.0.
Pathological types, 2-18 per cent.
Immature spermatozoa, up to 3 per cent.
Coefficient of variation of sperm head, up to 4.4.

Investigations in Kenya

In 1935-1937 250 pure-bred and grade bulls on 33 farms in different parts of Kenya were tested for sperm production and their genital organs were examined clinically. In addition, the testes and epididymes of 82 Zebu bulls were examined clinically. Breeding records of pure-bred and grade bulls were examined when available. The testes and epididymes were examined by inspection and palpation and any irregularities in size and shape noted. The seminal vesicles and ampullæ were examined per rectum and the condition of the penis was noted when the bull served the artificial vagina.

The artificial vagina was used exclusively for the collection of bull sperm and it is considered to be a highly satisfactory method. The method used is the same as that for collecting sperm for artificial insemination (Walton, 1936; Anderson, 1937). The ejaculate is examined microscopically, using a low-power lens, for density and motility of spermatozoa. This examination should be made as soon as possible after collection and in no case should there be a lapse of more than a few minutes. A hanging drop preparation should be used and in order that the sperm be examined under optimum temperature conditions, since a fall in temperature lessens motility, a warm stage at a temperature of 37° C. should be fitted to the microscope. Under field conditions it may not always be practicable to use a warm stage, but great care must be exercised to ensure that poor motility is not due to cold surrounding temperature or to placing sperm on a cold slide. Drying of the sperm on the slide also lessens motility. A rough estimate of the number of spermatozoa can be made by using the designation " D " when the microscopic field is densely filled with spermatozoa, " R " when spermatozoa are rare, " M " when they are intermediate in number, and " A " when they are absent. Motility is estimated as " very, very active " (vva) when there is very active energetic movement; in its highest degree this takes the form of characteristic turbulent wave movements. Movement is estimated as " very active " (va) when motility is less active than in the previous case, as " active " (a) when movement is still forward but not of an energetic nature, as " sluggishly active " when feeble forward movement is exhibited, as " oscillatory " (o) when a feeble rotatory movement is present, and as " nil " when motility is absent. The number of spermatozoa " vva," " va " or " a " motility is denoted on a 10 point scale, e.g., if all the spermatozoa appear to show very, very active movement the sperm is classified as " vva10," if only 90 per cent. of the spermatozoa show this movement it is classified as " vva9," etc. This method of estimating motility is not highly satisfactory, but with experience an observer can form a fairly reliable opinion of the relative motility of different sperm specimens. There is no difficulty in distinguishing a good specimen from a bad one.

Accurate knowledge of the density of the spermatozoa can be obtained only by use of the hæmocytometer. The counts reported in this paper were

made with a Buerker hæmocytometer, using 3 per cent. NaCl as a diluent. For estimating the number of abnormal and immature spermatozoa Williams's staining method as given by Lagerlof (1936) was used. Great care must be taken in making slides for this purpose. If the sperm smear is made by placing a drop of sperm on one slide and drawing it out with another slide as in making blood slides gross damage can be done to the spermatozoa and an entirely unreliable and false count of pathological types obtained. A drop of sperm is diluted in a test-tube with 0.9 per cent. NaCl to a watery consistence which permits of the easy observation of individual spermatozoa. A drop of this diluted sperm is placed on a slide and allowed to run over the surface of the slide by holding the slide at an angle or else it may be drawn out by another slide without allowing the two slides to touch each other.

The bulls described in this paper have been divided into four main groups. The bulls in Group 1 can be regarded as fertile bulls for the following reasons: (a) their sperm conformed to the recognised standards for fertility; (b) some of the bulls included in this group have been proved of high fertility in artificial insemination experiments; and (c) some of the bulls were known to be fertile from their breeding records. The bulls in Group 2 can be regarded as of "reduced" fertility. Some of them may actually have been sterile at the time of test, but it is not at present possible to draw a hard and fast line between fertility and sterility on the basis of sperm examination. Their sperm, however, fell short in one or other way of the generally accepted standards for fertility. Most bulls producing the Group 2 type of sperm would not be considered suitable for artificial insemination. The bulls in Group 3 were all sterile; they ejaculated either very poor sperm or no spermatozoa at all and many of them had clinical signs of disease in the genital organs. Group 4 contains those bulls which were clinically free from disease of the genital organs, but which refused to serve at the time of test.

Incidence of Sterility

The percentage of the bulls in each of the four groups is shown in Table 2.

TABLE 2.

	No. of Bulls	*% of Bulls*
Group 1	86	34.4
Group 2	32	12.8
Group 3	105	42.0
Group 4	25	10.0
Total	248	

Two other bulls examined clinically but not tested.

Only 34.4 per cent. of the bulls examined could be regarded as eminently satisfactory for breeding purposes and 12.8 per cent. were probably of "reduced" fertility. Group 3 comprises 105 bulls (42 per cent.) which were sterile at the time of examination. Ninety-one bulls (36.4 per cent.) were completely and permanently sterile because of clinical abnormalities in the genital organs, particularly in the epididymis. Fourteen other bulls ejaculated either no spermatozoa or spermatozoa of very poor quality, but showed no clinical signs of genital disease. Twenty-five bulls (10 per cent) failed to serve when tested. A total of 130 bulls was thus proved sterile when submitted to sperm test and clinical examination. Some of the bulls which either failed to serve or produced no spermatozoa or spermatozoa of very poor quality may have been only temporarily sterile (these bulls number 39 = 15.6 per cent.). It is probable, however, that some of the bulls which produced no spermatozoa or spermatozoa of a very poor type were in the early stages of epididymitis before clinical signs of the disease were evident.

STERILE BULLS (GROUP 3)
TABLE 3

No. of Bulls	*Clinical Finding*	*Sperm Examination No. of Bulls with Sperm*			*No. of Bulls with Inability to Serve*
		Poor	*Nil*	*A*	
78	Epididymitis	7	5	40	26
10	Testicular abnormality	2	1	2	5
3	Abnormality of penis ...	–	–	–	3
14	Normal	–	8	6	–

The most important cause of sterility was epididymitis. This was diagnosed clinically on 21 of the 33 farms, in 78 out of 175 bulls (44.6 per cent.). It is probable, however, that the actual incidence on these farms was higher since the conditions must be relatively far advanced before it can be recognised clinically. (Recently this condition has been found on a farm on which the bulls were not clinically affected at the time of the tests reported in this paper.) This condition affects both pure-bred and grade bulls. It has not been found in Zebu bulls, though it is known to the Masai who regard it as a form of venereal disease. It has been found in the following breeds: Ayrshire, Friesian, Guernsey, Red Poll and Shorthorn.

The loss to the cattle industry in Kenya from this form of sterility is serious. Approximately two-thirds of the 91 affected bulls were pure-bred bulls. If pure-bred bulls are valued at the conservative figure of £50 per head and grade bulls at £20 per head, the loss exceeds £3,600 for those bulls actually examined and this figure does not include bulls sterile for other reasons, the cost of replacing sterile bulls, nor loss of income from poor birth-rate, fall in milk supply and sterility in cows associated with epididymitis in the bull. One farm alone had 25 pure-bred bulls affected.

The Kenya Agricultural Census of 1936 gives the number of bulls, both

pure-bred and grade, as 2,268 and on this basis the number of bulls tested would represent about 11 per cent. of the total adult bulls on European-owned farms (this number does not, of course, include Zebu bulls). It is not known to what extent these figures reflect conditions of bull fertility and sterility in Kenya generally. The incidence of sterility in the 250 bulls described in this paper may be higher than that for the country generally, since in many cases bulls were tested presumably because the owner suspected something wrong. Investigations subsequent to those described here have proved, however, that the condition is even more widespread than was suspected.

Clinical Examination of the Genital Organs of Bulls in Kenya

It was found that 78 (31.2 per cent.) of the 250 bulls examined showed easily recognisable changes in the epididymis and 10 (4 per cent.) in the testes (Table 3). In many cases these changes could be determined by inspection, in that the testes were hanging very low and the testes and epididymes were increased in size and irregular in outline (Figs. 1-6). On palpation the tail of the epididymis, sometimes also the head, and more rarely the body, were found to be increased in size, up to about the size of a cricket ball, and indurated. In some cases the testes were also increased in size and indurated, but in others, and more usually, they were reduced in size. Sometimes one testicle was normal in size and the other reduced in size. It may, however, be difficult to determine the actual size of the testis by palpation if there is gross involvement of the epididymis. Commonly, both epididymes are affected, but the tail of one may be considerably larger and more indurated than the tail of the other. The tail of the epididymes was often firmly adherent to the adjoining part of the scrotum, which prevented normal movement of the testes in the scrotum. In some bulls, however, which were indifferent or bad sperm producers, no abnormalities could be detected in the testes or epididymes by inspection or palpation.

It was possible to follow the course of development of this condition in eight bulls. Bull No. 225 on January 20, 1937, had normal testes and epididymes; on July 2, 1937, the tail of the left epididymis was enlarged and indurated. The testes and epididymis of bull No. 232 appeared normal on January 29, 1937, and on July 2, 1937, the tail of the left epididymis was slightly enlarged but not indurated. Bull No. 236 in January, 1937, had an enlargement of the tail of the left epididymis, and in July both tails were enlarged and indurated. The tail of the left epididymis of bull No. 235 in January, 1937, was enlarged (golf ball size) and indurated; in July it was greatly enlarged (orange size) and indurated and the tail of the right epididymis was also enlarged and indurated. In January, 1937, the left testis of bull No. 120 was found to be very small; there was no change by March 4, but by April 24 the tail of the right epididymis was slightly indurated, and by July 20 it was much more indurated. Bull No. 119 on December 9, 1936,

had a slight enlargement of the tail of the right epididymis, and on March 9, 1937, the tails of both epididymes were enlarged and indurated (golf ball size). Bull No. 111 was under observation for 14 months. In June, 1936, his penis bled when serving. The testes and epididymes were normal up to April 16, 1937. On August 27, 1937, however, the left testis was swollen and tender and the tail of the left epididymis was enlarged and indurated. On February 25, 1937, the tail of the right epididymis of bull No. 109 was enlarged but not indurated, but by April 12 induration had taken place. It therefore appears that this condition in the epididymis is capable of fairly rapid development.

The number of bulls with clinically recognisable changes in the testes alone was small. In two bulls (Nos. 56 and 95) both testes were swollen and in two others (Nos. 57 and 221) the left testicle only was slightly enlarged. In three bulls (Nos. 63, 98 and 153) both testes were smaller than normal; in two other bulls (Nos. 86 and 108) the left testicle was abnormally small, and in another bull (No. 249) the right testicle was abnormally small and situated in the abdominal muscles.

In only four bulls did the seminal vesicles appear to be abnormal on palpation (bulls Nos. 82, 85, 87 and 112) and this took the form of increase in size and firmness.

Abnormalities were found on the penis in four bulls (Nos. 23, 62, 111 and 227). No. 227 had a small left testicle. In this bull about eight inches from the glans there was practically a right-angle bend in the penis which prevented the insertion of the penis into the vagina. The penis or the mechanism for erection also appeared to have been injured in bulls No. 23 and 62 in that these bulls, while keen to serve, did not have a proper erection. (This condition appears similar to that described by Gotze, 1934.) On June 17, 1936, bull No. 111 bled from the penis on serving the artificial vagina, but seven other ejaculations in June contained no blood. On November 20 and December 3, 1936, however, the penis again bled. Ejaculations in January, March and April, 1937, contained no blood, but in August the penis was swollen and congested, and although the bull was keen to serve he was unable to get his penis out of the sheath for service. A fifth bull, No. 226, appeared to ejaculate blood, but it was impossible to determine the actual site of bleeding.

Ability and Desire to Serve

Desire to serve is recognised as absent when a bull refuses to serve, and not keen, fairly keen, keen, and very keen, according to the eagerness with which a bull serves. A good service is easily recognised by the forward and upward thrust given by the bull after the penis enters the vagina of the cow or the artificial vagina. Some bulls exhibit more powerful thrusts than others. In the absence of such a thrust a bull very rarely experiences a proper

ejaculation. A bull may mount a cow once or oftener before having this final thrust and during these preliminary jumps variable amounts of more or less clear seminal fluid may be ejaculated. A bull is not considered to have served unless this final thrust is noted. No difficulty has been experienced in getting sexually mature bulls of all ages to serve the artificial vagina at the first attempt. Bulls which will mount a cow will usually ejaculate, though all bulls do not do so with equal speed. Some bulls may refuse to mount a cow on the first attempt or they may mount but do not ejaculate. Such bulls, however, often serve well on second or subsequent attempts. It is considered that bulls which do not serve promptly and vigorously on being led up to a cow are suffering either from diminished sex desire or from some form of inability to copulate due to, for example, injury to the penis or incomplete erection. Usually, however, bulls affected by these latter conditions are willing to serve and they will mount a cow, but are unable to complete the act of copulation. Bulls which refused to serve were in practically every case those which showed no interest in the cow and refused to mount the cow. No difficulty has been experienced in testing bulls on farms where no cows were on heat. If a quiet cow, not on heat, is tied up to prevent her moving about, a bull with normal sex desire will usually mount her and serve the artificial vagina.

Bulls of all grades of fertility have been found to exhibit great variation in their ability and desire to serve, and not uncommonly a completely sterile bull will be much keener and more capable of service than a highly fertile bull. A big, heavy bull may be slow at service, but if left with a cow on heat for some time very often eventually serves her.

The eight bulls which were observed during the development of the epididymitis were all fairly keen to very keen to serve. Of the 250 bulls examined 59 refused to serve. Three of these 59 bulls were unable to complete the act of erection and were thus unable to serve. The remaining 56 showed faulty sex impulse. Thirty-one of these latter bulls were affected in the testes and epididymes, but the remaining 25 showed no clinical abnormalities. Many of these bulls were in large herds where it was the practice to run the bulls with the cows and it is considered that the faulty sex impulse may have been due, in a large measure, to overwork. It is quite clear, however, that a bull with chronic epididymitis is capable of normal vigorous service, but it is not known if such bulls eventually lose all desire to serve.

Bull No. 111, which ejaculated blood in June, November and December, 1936, showed less inclination to serve on these occasions, but in August, 1937, when the penis was acutely inflamed, he was keen to serve, but could not do so because of inability to protrude the penis.

Sperm Investigations

Physical Properties.—The appearance of ejaculates was very similar to that noted by other workers. The ejaculate of a normal bull of good fertility

is an opaque, whitish or whitish-yellow fluid of milky or milky-creamy consistence. Usually the thicker and the more creamy-like the ejaculate is, the higher is the concentration of spermatozoa and conversely a thinner, more watery, less opaque fluid of a bluish-white colour contains a smaller concentration of spermatozoa. A thin, watery specimen contains few or no spermatozoa. Occasionally the ejaculate may be of a greenish-yellow colour. Although the appearance of the ejaculate depends mainly on the number of spermatozoa present, there are exceptions and a few ejaculates which are milky in appearance contain few or no spermatozoa.

Overwork has been noted as a cause of the ejaculate becoming thin and watery, but the main cause was abnormalities in the genital organs. The ejaculate from bulls with chronic changes in the epididymis was very seldom normal in appearance. Such specimens were in the following order of importance: watery with lumps of mucus, milky with lumps of mucus, watery and thick mucus. Watery ejacula were obtained from some bulls before clinical abnormalities in the epididymis were detected. Other bulls, which were clinically normal at the first examination and produced milky ejacula, at a later examination had suffered enlargement and induration of the epididymis and produced watery specimens.

Those bulls with abnormally small testes which were capable of service produced thin, milky ejacula or milky or watery ejacula with lumps or floccules of mucus, and one bull (No. 249) produced thick mucus. It is possible, however, that such bulls may have been affected by commencing epididymitis, as well as testicular under-development or hypoplasia. The four bulls in which clinical changes in the seminal vesicles were detected produced milky or watery ejacula with lumps or floccules of mucus. Some bulls, e.g., No. 111, produced ejacula containing blood.

Volume.—In Table 4 particulars of the volume of the ejaculate in bulls in the different groups is shown. The average volume of the ejaculate was reduced in young bulls, in bulls of "reduced" fertility and in sterile bulls.

VOLUME OF EJACULA

TABLE 4

	No. of Bulls	*No. of Ejacula*	*Mean*	*Volume Standard Deviation*	*Range*
Group 1					
Adult bulls	61	304	5.13±0.13	2.2	1.0—12.0
Young bulls	25	90	4.18±0.23	1.9	1.7— 9.0
Group 2	32	60	3.88±0.23	2.0	1.2—11.4
Excluding 8 young bulls	24		4.35±0.32	2.2	1.2—11.4
Group 3					
Epididymitis	52	94	3.61±0.20	2.0	0.5—12.0
Testicular abnormality	5	9	3.0	—	—

(*To be concluded.*)

OBSERVATIONS ON THE ETIOLOGY AND CONTROL OF FOWL PARALYSIS

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A PREVIOUS publication describes an outbreak of fowl paralysis in 1934 in a flock which was previously healthy, and the measures taken in an attempt to control the disease. Mortality from fowl paralysis and also from coccidiosis was materially reduced in 1936 by removing newly hatched chicks from the affected plant to fields of a small outlying farm (called Parkhead) where they were reared under a separate attendant. The percentage mortality due to fowl paralysis was .89 per cent., compared to 14.01 per cent. in the controls at the parent plant on the same diet as those at Parkhead.

Final Results of Experiment I

The results published covered the first ten months of the experiment which was then continued for a further 13 months. During the latter period only one case of fowl paralysis occurred at Parkhead, but the incidence in the control group rose to 31.4 per cent. Table I shows the principal causes of mortality of both groups.

TABLE I

Progeny of 1933 *White Leghorns*

	Parent Colony	*Parkhead*
Number of pullets at two months 1.6.36 ...	207	450
Total mortality to January 31, 1938	76.8	20.9
Analysis of Post-mortem Findings		
Fowl paralysis	31.4	1.11
Atrophy and degeneration of internal organs ...	3.4	—
Impaction of digestive tract	5.8	—
Nephritis	6.3	0.4
Coccidiosis	12.5	1.1
Tumours (not fowl paralysis)	1.0	1.3
Peritonitis, impaction of oviduct, prolapse, etc.	10.1	15.29
Contagious catarrh	1.0	—
Other causes	5.3	1.7
Egg production per pullet to 31.1.38	75.1	217.3
Average weight at six months	3.24 lb.	3.87 lb.

The majority of the survivors in the control group were of practically no commercial value, many being emaciated and having that peculiar eye condition associated by many workers with fowl paralysis. The survivors at Parkhead presented a striking difference, being bright and healthy and possessing good body weight and high egg records.

When the isolated colony at Parkhead was first established it also included 240 Rhode Island Red pullets. These were not considered as part of the experiment as no controls were kept. No cases of fowl paralysis occurred in this group at Parkhead, but when 45 birds were moved back to the parent colony when 5½ months old three cases of fowl paralysis resulted, the first being noted 146 days after transfer.

The remaining 200 birds were shifted to the parent colony when 12 months old and two cases of fowl paralysis resulted, the first occurring 84 days after transfer.

No definite reason can be given for the very marked fall in the incidence of fowl paralysis and disease generally in the stock at Parkhead. Apart from any hypothesis of the absence there of a specific infective agent, there was a marked difference in the degree of internal parasitism present and a variation in the quality of the pasture and the ranging space provided. Birds in the parent colony were confined in runs which had been used for several years and which were contaminated by coccidia and worms, whereas at Parkhead the pasture was of better quality, had not been used for poultry, and the birds were allowed to range at will.

The houses, too, were of a smaller type which may have induced the birds to spend more of their time outside.

Experiment Ia

As we were anxious to see whether the disease would flare up in the Parkhead colony if breeding was continued there, a fresh batch of chicks derived from that stock was reared there in 1937. Contrary to expectation, the health of this new batch turned out very similar to that of the parents. In a sister group (Clinterty) which was established on new ground over a mile away, however, the mortality and incidence of fowl paralysis rose to a substantially higher figure (see Table II), though the feeding and houses were kept as similar as possible. This increase in the disease could certainly not be accounted for by an increase in parasitism. There were very few worms in both lots and there is evidence that in this new group infection of coccidia was extremely light and there were no deaths from this cause. The possibility that infection of some other unknown agent was heavier in this new colony cannot, of course, be ruled out. Another interesting fact for which no explanation can at present be offered is that in the two flocks which were reared on clean range very few typical cases of paralysis of the legs or wings occurred, and nerve lesions were rarely observed. Lesions in the liver, spleen and

kidneys, on the other hand, were even more common than in the parent colony where neurolymphomatosis was so prevalent.

The groups in these experiments are sufficiently large to allow deductions to be made from the results with safety. We have evidence that some unknown but highly important factor may influence the severity of the disease quite independent of the genetical constitution of the birds or of the degree to which they are parasitised with worms and coccidia.

TABLE II

	Parkhead	*Clinterty*
Number of pullets at eight weeks (13.5.37) ...	192	203
Total mortality to 31.3.38	9.9%	16.74%
Mortality in which diagnosis made	9.9%	15.76%
Analysis of Post-mortem Findings		
Injury, accident, cannibalism	2.08	0.99
Peritonitis, impaction of oviduct, prolapse, etc.	1.56	0.49
Fowl paralysis	2.6	9.36
Impaction of digestive tract and indigestion ...	—	0.99
Coccidiosis	1.04	—
Tumours (not fowl paralysis)	.52	1.48
Other causes	2.08	2.46
Egg production per pullet reared	109.68	99.03
Average weight of pullet at six months of age (lbs.)	4.059	4.096

Isolation Experiment (Experiment II)

In order to study the disease complex more closely another line of approach was developed in 1937.

To investigate the influence of certain factors on the incidence of fowl paralysis large groups of fowls of known history and an efficient system of isolation seemed to be essential.

Previous experience in 1935 and 1936 impressed us with the difficulties such isolation involves, for in spite of a separate attendant and separation of the new unit from the old by a distance of two miles, isolation was far from complete and infestations with coccidia, three species of helminths, and lice occurred.

It was decided that all stock must be kept inside, and for this purpose special intensive houses were designed. These were situated on either side of the main plant and about 400 yards distant from it. The houses were similar in design to those of the parent plant, but extra accommodation was provided for food and litter. Fly-proof screens were fitted over the windows and ridge ventilators, and a screen of fine mesh netting wire enclosed the whole erection to exclude rats, birds, and other possible carriers of infection.

Water taken from the main supply of the Institute was available from a tap inside the screen. Trap doors were fitted in the roof, through which the monthly food supply and litter could be delivered, and the soiled litter in paper bags removed. A special attendant was employed for each house and the situation of the isolation houses in relation to the abode of the worker rendered it unnecessary for the attendant to cross any ground on which birds were kept. A room was provided in the isolation house where the attendant changed into special clothes and a telephone was installed to allow daily contact with headquarters. The ingredients of the mash were mixed in the store of a commercial food company and delivered once a month, part to the isolation and part to the controls. The food was delivered in new bags and as an additional precaution the bags themselves were not allowed inside the house.

No special fittings, such as wire floors, were provided, and no special hygienic measures were adopted as it was desired that if an initial infection with coccidia occurred the conditions should be such as would allow the disease to flare up and indicate immediately that isolation had broken down. On the other hand, it was believed that if an examination of samples of fæces from time to time revealed the absence of oocysts there would be some justification for assuming that isolation had been satisfactory.

Two poultry stocks of known history were available. One was the flock of Brown Leghorns kept by Dr. Greenwood at the Institute of Animal Genetics, Edinburgh University, and the other the flock of White Leghorns at the Rowett Research Institute.

Up to that time no cases of fowl paralysis had been diagnosed in the flock at the Institute of Genetics. On the other hand, we have shown that this strain of Brown Leghorns does not possess any immunity to this disease. When reared in the affected plant at the Rowett Institute in 1936 they developed typical lesions (Johnston and Wilson, 1936).

With regard to the other flock chosen there had been a high incidence of fowl paralysis during the preceding three years. Survivors of these three years, as well as a few birds still remaining from the healthy stock which existed prior to 1934, were selected for breeding.

It was proposed to rear a large group of Brown Leghorns and a large group of White Leghorns in isolation, and to rear an equal number of controls under exactly similar conditions but exposed to whatever infection, parasites, etc., might be present in the diseased colony. It was expected that the controls, though reared continuously indoors and fed a suitable diet, would develop the disease as in the previous year when they were allowed outside and fed a different diet. The question was whether the sister groups reared in the isolation houses would also develop this condition. If the disease developed as a result of exposure to specific infection the Brown Leghorns in isolation should remain free. The White Leghorns, on the other hand, might still

develop the disease in isolation if this specific infection was transmissible to the progeny through the egg.

The Brown Leghorns were hatched in Edinburgh in eight separate batches. All chicks were pedigreed and wing banded and on arrival were taken straight to the isolation house (D) where they were divided into two equal lots, one lot remaining in the isolation house and the other transferred to a control house in the diseased colony (E).

The White Leghorns were hatched in a forced draught incubator at the main poultry plant of the Rowett Institute as four separate batches, the chicks wing-banded, and those from each individual hen carefully distributed over the two groups. One lot was taken to isolation house (W) and the other transferred to a control house in the diseased plant (L).

Hatching from both flocks was spread over a two-month period, commencing on March 16 and finishing on May 18. This allowed a sufficient number of chicks to form two large groups of pullets (the cockerels were killed as soon as sex could be determined) to be obtained from a comparatively small breeding stock and also ensured that there were several groups of fowls of different ages under experiment, in order to find the time of greatest susceptibility to whatever infection was present.

Samples of fæces were examined for the presence of coccidia on May 25, June 14, June 25 and July 6 with negative results in each case for the isolation birds, but strongly positive in the case of the controls.

TABLE III

Incidence of Fowl Paralysis in White Leghorns at Different Ages.

	Experiment I 1936		*Experiment Ia* 1937	
	Parent Colony A	Isolated Colony B Parkhead	Isolated Colony B	Isolated Colony C Clinterty
Number of birds in group	207	450	317	600
Number of cases of F.P.				
Before 8 weeks	—	—	—	—
8-12 weeks	—	—	—	—
12-16 „	2	—	—	—
16-20 „	3	—	—	2
20-24 „	7	2	—	5
24-28 „	3	—	1	6
28-32 „	4	2	3	6
32-36 „	5	—	—	4
36-40 „	6	—	1	7
40-44 „	4	—	1	2
44-48 „	3	1	—	1

During that period four cases of fowl paralysis developed in Brown Leghorn control group E. This was somewhat earlier than previously observed in our experiments, as it has been unusual for several birds to be affected before the 20th week. (See Table III.)

Samples of fæces examined on August 17 revealed coccidia in all groups and in the case of the White Leghorn isolation group W in relatively large numbers. On August 22 fæces from this group were slimy and contained specks of blood, and there was a fall in egg production.

In Brown Leghorn group D examination for coccidia on August 28, September 1 and 10, failed to reveal oocysts. Diarrhœa developed on the latter date; a fall in egg production occurred and oocysts were present in samples of fæces collected on September 18.

TABLE IV

	Brown Leghorns		*White Leghorns*	
	Isolated Group D	Control Group E	Isolated Group W	Control Group L
Number of birds in group				
Number of cases of Fowl Paralysis				
Before 8 weeks	—	1	—	—
8-12 weeks	—	4	—	—
12-16 „	—	3	—	—
16-20 „	—	3	—	3
20-24 „	—	—	5	7
24-28 „	—	—	—	3
28-32 „	1	1	—	1
32-36 „	—	—	—	—
36-40 „	1	—	1	—
40-44 „	1	1	1	—
44-48 „	—	1	2	3

By the end of August, ten cases of fowl paralysis had been diagnosed in Brown Leghorn controls and two in the White Leghorn controls. On September 20 the first case appeared in White Leghorn isolation group W, and during October several further cases occurred in this group and in the controls.

As no cases had occurred in the Brown Leghorn isolation group D, it was speculated that although the isolation had broken down sufficiently to allow the entrance of coccidia it might have been sufficient to exclude fowl paralysis.

However, the disease was eventually diagnosed in a bird from this group which died on November 28 at the age of 31 weeks, and two further cases occurred at the 36th and 40th weeks. Meantime, a marked improvement in the general health and production of control group E was noted, and only one case of fowl paralysis developed between the 20th and the 44th week.

Table IV shows the age incidence in the isolated and control groups.

The figures for the isolation experiment suggest that the cause of the disease was present in the main colony from the beginning of the experiment and that it was introduced into the isolation group D at a much later date, possibly when the birds were accidentally infected with coccidiosis.

It must be recorded that another complicating factor has arisen, for several cases of fowl paralysis have been diagnosed in the Brown Leghorn plant at Edinburgh and this has a material effect on any interpretation of the results.

TABLE V

	E	D	L	W
Number of pullets at 8 weeks ...	416	394	184	188
Total mortality (per cent.) to March 31	12.02	3.05	17.93	7.45
Mortality in which diagnosis made	10.34	2.79	17.39	7.45
Analysis of P.-M. Findings				
Injury, accident and cannibalism ...	1.92	0.76	0.54	0.53
Peritonitis, impaction of oviduct, prolapse, etc.	0.24	0.76	1.62	0.03
Contagious catarrh	—	—	1.08	—
Fowl paralysis	3.37	0.76	10.87	4.70
Atrophy and degeneration	0.24	—	—	—
Impaction of digestive tract and indigestion	1.68	—	0.54	—
Nephritis	—	—	1.09	—
Coccidiosis	1.20	—	—	—
Tumours (not F.P.)	—	—	—	1.07
Other causes	1.68	0.51	1.63	0.53

The experiment was continued until March 31, 1938, and the final results are given in Table V. It will be noted that up to that time the incidence was still very much lower in the isolated groups than in the controls, the figures being .76 per cent. and 3.37 per cent. in the case of the Brown Leghorns, and 4.7 per cent. and 10.87 per cent. in the White Leghorns.

Microscopical Examination of Tissues of Birds Destroyed After Termination of Experiment II

Since it was impossible to carry on this experiment for a period comparable to Experiment I, it was considered desirable to have some knowledge of the condition of the birds at the termination of the experiment.

Between January 11 and March 18, 50 Brown Leghorn fowls from group

D and 50 from group E were destroyed and post-mortem examinations carried out. These included all the remaining full sisters of birds which had developed lesions of the disease. The method of examination was similar to that described in a previous paper. In only one case (from group D) was macroscopical evidence of fowl paralysis noted.

The material chosen for microscopical examination was the right and left brachial plexuses, right and left sciatic nerves, vagi (in certain cases), portions of the cervical, thoracic and lumbar spinal cord and portions of certain organs in individual cases. Transverse sections of the fore, mid, and hind brain were also selected. Usually about 12-15 sections of each portion of nerve and 8-10 sections of each portion of the brain were examined.

TABLE VI

Isolated Group		Non-Isolated Group	
Bird No.	*Disease present in*	*Bird No.*	*Disease present in*
12	Left brachial plexus	595	Left sciatic
72	Right brachial plexus and lumbar spinal cord	676	Left brachial plexus
147	Right and left sciatics	660	Left sciatic Right and left brachial plexus
135	Left sciatic	12	Left brachial plexus
182	Right and left brachial plexus Right and left sciatics Fore and mid brain, cervical and lumbar cord	72	Lumbar spinal cord and right brachial plexus
249	Left sciatic	595	Left sciatic
224	Both vagi	147	Right and left sciatic
		135	Left sciatic
		636	Right brachial plexus
		189	Right sciatic, left sciatic Right brachial plexus and left brachial plexus. Fore and mid brain; cervical and lumbar cord
		660	Left sciatic. Left brachial plexus and right brachial plexus
		249	Left sciatic

What were considered to be typical lesions of neurolymphomatosis were found in seven cases from the isolated group and in three from the non-isolated group. In several nerves which appeared normal to the naked eye relatively advanced microscopic lesions were noted. In other cases the lesions were less marked, but the infiltration of lymphocytic cells was always greater than that occasionally found in apparently normal birds. Microphotographs illustrate the types of lesions present, and Table VI shows the lesions in each fowl.

A more minute examination of other nerves than those selected might have revealed further cases so that the number of positive cases must be considered a minimal one.

If the number diagnosed by microscopical examination are added to the number of cases at the termination of the experiment, it is found that out of 394 pullets kept under isolation, ten cases of fowl paralysis were diagnosed as compared with 14 cases out of 416 controls—an insignificant difference.

The important difference in the two groups is that an interval of six months elapsed between the first case in the Brown Leghorn control group and the corresponding isolated group.

Discussion

To be successful Experiment II depended on the raising of two stocks of known history under conditions of isolation. Complete isolation was not achieved, so that the results, though suggestive, are not conclusive.

In Experiment II the feeding, housing and methods of rearing adopted were absolutely similar, so that the difference in incidence of fowl paralysis noted cannot be attributed to any of these factors. The genetic constitution of the birds comprising the stock was as carefully controlled as possible. Each of the comparable groups was derived from the same breeding stocks, each group being made up from several breeding pens. Care was taken that the progeny of each pen was equally distributed. Table VII shows how the daughters of each breeding pen were distributed over the groups in which the incidence of fowl paralysis was later found to be low and high respectively. The figures leave no doubt whatever that some factor other than heredity plays a major role in the causation of the disease.

TABLE VII

Distribution of Progeny of Each Breeding Pen

		Number of pullets at 8 weeks		*Incidence of fowl paralysis per cent.*	
	Breeding pen	*Low group*	*High group*	*Low group*	*High group*
	(a)	57	49	0.	6.12
Experiment Ia	(b)	48	50	8.29	18.00
	(c)	45	54	0.	9.26
	(d)	42	50	0.	4.00
Experiment II	(a)	42	50	2.4	10.00
White Leghorns	(b)	60	45	6.67	8.9
	(c)	35	34	2.86	2.94
	(d)	38	41	2.63	12.2
Brown Leghorns	(a)	145	133	0.	1.5
	(b)	116	152	0.	1.97
	(c)	70	63	1.43	7.94
	(d)	23	31	4.35	0.
	(e)	40	37	0.	2.7

In order to explain the difference in comparable groups parasitism in its widest sense is the only factor to be considered. Worm counts were carried out by Dr. Morgan, of the Royal (Dick) Veterinary College, on most of the birds submitted for post-mortem examination. In Experiment I many of the control birds were heavily infected with several species of helminths, but in the fowls reared on clean range the numbers present were too small to be significant. In Experiment II worms were absent from isolated groups D and W and in the controls E and L, which were also reared indoors, only a few birds carried worms, and the numbers were small.

Coccidia were present in every group of birds under experiment and the severity of the infestation varied very greatly. In Experiments I and II the disease was much more severe in the control groups in the parent colony than in the isolated groups. In Experiment II the isolated groups, which suffered a lower mortality from paralysis, were coccidia free during the first four months.

The connection between coccidiosis and fowl paralysis is very striking. No case of fowl paralysis was diagnosed in any group prior to the finding of coccidia in the particular group involved. This may be purely coincidental for Dalling and Warrack (1936) and others have shown, and it is also our experience, that typical fowl paralysis may develop in coccidia-free birds.

It must be admitted that the differences between the comparable groups of Experiment II are comparatively small and might easily be accounted for by the differences in the infestation of coccidia. If it is assumed that these differences represent the effect of parasitism, the latter can only partially explain the difference in incidence of fowl paralysis in Experiment I. There seems to be some other factor of importance which determines the incidence of this disease. We have already referred to the unexpected increase in disease in the Clinterty group of Experiment Ia.

The question now arises whether these unaccountable fluctuations in the disease are mainly fluctuations in the intensity of a separate infection or the result of some other environmental factor.

It should be noted that in the control group of Experiment II as compared with the control of Experiment I there has been a lowered incidence of the disease which coincides with the change-over in diet and management. If this reduction in mortality were solely due to an acquired immunity in the stock one might expect a corresponding drop in the isolated groups. But there were actually more cases of the disease in the isolated groups in Experiment II, though the isolation was undoubtedly more complete than it had been in the first experiment.

It would therefore seem that when the conditions for isolated and non-isolated groups were made identical and the simple effect of isolation remained, the difference in the incidence of fowl paralysis was greatly diminished.

The behaviour of the isolated and non-isolated White Leghorns in

Experiment II was strikingly similar. It has already been mentioned that these were brought out in four separate batches, each of which was divided equally over the isolated and control houses. Lot 4 in the control house was the only one in which losses from coccidiosis occurred and was the only lot in which the incidence of fowl paralysis was higher than in the corresponding lot in isolation. But there is no apparent explanation for the other fluctuations in the disease which, as may be seen from Table VIII, are so similar in each house. All birds in this experiment were marked at hatching so that the parentage of individual birds could be traced later. It is possible to say, therefore, that most of the pullets which developed fowl paralysis in the third and fourth batches had sisters in the first and second batch, yet the latter did not develop the disease.

TABLE VIII

White Leghorns	*No. of pullets (8 weeks)* Non-Isolated	Isolated	*Mortality from F.P.* Non-Isolated	Isolated
Hatch I (March 16) ...	32	42	1	1
Hatch II (April 6)	42	52	0	0
Hatch III (April 27) ...	48	49	4	4
Hatch IV (May 18) ...	62	45	11	3

The results obtained when 100 apparently healthy birds were destroyed and definite evidence of neurolymphomatosis revealed in ten cases, following histological examination, shows the necessity of carrying out the latter procedure in every case if experimental results are to be of any value. This point is stressed by Blakemore and Glover (1934), who state: "Unless this procedure is followed it is impossible to determine even approximately the incidence of the disease."

It also indicates that the disease is even more prevalent than published figures would suggest, as such figures must of necessity be minimal ones, it being manifestly impossible to carry out detailed histological work in dealing with ordinary routine work as opposed to research.

The results of the experiments recorded here, together with those in a previous paper by us (1937), though they do not afford conclusive proof, give support to the hypothesis that the disease is due to a specific infection. This hypothesis was strengthened by the fact that Harriss (1939) reproduced the disease in a pheasant by inoculating material from an infected fowl, and seems to be confirmed by Blakemore (at the Institute of Animal Pathology, Cambridge), who, by inoculation, has produced the disease in fowls which were presumably previously free from it.

One of us (J.E.W.) has also produced typical cases of fowl paralysis following the injection of filtrates of affected nerves and tumour material into fertile eggs and chicks.

If it can be assumed as proved that we are dealing with an infectious disease, one of the main lines of attack must be controlled by hygienic measures.

The observations made by us in the last three years seem to indicate the possibility of markedly reducing the incidence of the disease by improved methods of management specially designed for that end.

Summary

1. These experiments are concerned with the influence of environmental factors on the incidence of fowl paralysis.
2. When newly hatched chicks were taken from the original plant, where the disease was prevalent, and reared on fields where poultry had not previously been kept, the mortality was very much lower than in the case of closely related birds reared in the original plant.
3. The disease appeared in birds hatched from eggs obtained from a stock free from disease but reared in the original plant.
4. Isolation, though proved by the appearance of coccidia to be incomplete, was effective in reducing the incidence of the disease and postponing the onset of symptoms.
5. The results obtained suggest that the disease is infectious and can be controlled by methods of management specially designed for that end.

The cost of the investigation referred to in this paper was defrayed by a special grant made by the Agricultural Research Council.

We wish to express our indebtedness to Professor D. M. Watson, F.R.S., Chairman of the Committee, Professor T. Dalling, of Cambridge, Dr. A. Greenwood, of the Animal Genetics Department, Edinburgh University, Sir John Orr, Major A. Crichton and Dr. A. H. H. Fraser, of the Rowett Institute, with whom the results were discussed from time to time for helpful criticisms, advice and suggestions. We are specially indebted to the two last-named for continuous interest and assistance.

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INHALATIONS

By G. MAYALL, M.R.C.V.S.
Bolton, Lancs.

THE application of drugs in a finely divided or gaseous state to the mucosæ of the nose, throat, air passages and lungs is a therapeutic measure not infrequently used in animals in bronchitis and influenza and inflammatory conditions of the throat and larynx.

Nasal insufflators, steamed hay in a bucket or nosebag, or medicated

steam into a loose box conducted from kettles outside into pipes passed through holes in the wall are methods of inhalation employed.

Steam itself or hot moist air has a very soothing effect on the mucosæ of the air passages. Volatile drugs that are not too keen are used to impregnate the steam.

Useful ones are compound tincture of benzoin, terebene, oil of eucalyptus and pinewood oil.

What is the physiology of the natural protectives of the respiratory organs?

It consists of the layer of mucus which covers the mucous membrane and the ciliated epithelial cells of the membrane, the cilia of which carry out by their movement any foreign bodies which may enter. At the same time, the air passages, with their extensive surface and recesses, serve to warm the air and filter out the dust. Finally, for the forcible removal of foreign bodies and disease products, there are certain defensive reflexes (coughing and sneezing).

What happens with a diseased respiratory mucosa?

As a result of catarrhal swelling of the mucous membrane or the deposit of thick viscid mucus and masses of exudate, the activity of the ciliated epithelium is reduced or suppressed. The same effect is produced when the cilia are involved by excessive catarrhal desquamation, inflammatory infiltration or ulceration, and also when they are paralysed by the products resulting from the decomposition of the retained bronchial contents (fatty acids). Cough, also an important natural healing force, is stimulated by the internal use of expectorant drugs. Research has shown that atomisers by which a fine spray of medicinal remedies are introduced into the nostrils and mouth in the human subject are only useful in animals where the region of the œsophagus, larynx and trachea are affected. The same applies to insufflation of fine powder. Vapours and gases penetrate to the deepest sections of the respiratory apparatus.

A long and interesting law case is reported in *The Journal of the American Medical Association* for July, 1939. The case was one in which a medical practitioner, Brunson, sued another called Fishbein concerning an alleged cure for tuberculosis (including the phthisical form) by the inhalation of an oily mixture administered by an atomiser. Brunson was the plaintiff and Fishbein the defendant. Fishbein asserted that it was impossible to cure tuberculosis by inhalation of oily mixtures of whatever composition, and those used in cases of T.B. were dangerous. Brunson asserted otherwise.

The defendant, Dr. Morris Fishbein, the editor of *The Journal of the American Medical Association* and several other important American medical journals, gave evidence on his own behalf and was supported by a number

of noted American medical men. Very full and expert evidence was given on behalf of Dr. Fishbein, and the verdict was: "We, the jury, under instructions of the Court, find in favour of the defendant, Morris Fishbein."

Incidentally, during the trial the question arose whether tuberculosis in the human subject could be cured. The following is a note of the evidence:—

Q.—In the final analysis in your opinion (Dr. Harry John Cooper) there is no cure for tuberculosis?

A.—I can't answer that because you do not define your term cured.

Q.—What does a cure mean, doctor, in your language?

A.—In my language there are two types of cures: a bacteriological cure is never attained, a tubercle bacillus can remain alive in the body for 25 years; a clinical cure can be achieved. That is an apparent cure and the reason for that is because all of the physical and pathological findings and all these things we are concerned with, toxicity begins to disappear and subside and the tubercle bacilli disappear from the sputum. We consider these cases apparently arrested; we do not call them cured.

So much for the use of an oily mixture and an atomiser to cure tuberculosis. Most men know the uses of intra-tracheal injections in "Hoose" of calves and intra-nasal injections of chloroform (15 minims) are said to be useful in verminous bronchitis of pigs.

In closing this article, we should like to state that in three cases of catarrhal pneumonia in valuable horses we made no impression on cloyed lungs and where the condition of the horses was at a standstill (as evidenced by temperature, respirations, auscultation and no nasal discharge) until we began using sodium iodide in full doses in bolus.

This drug is an alterative and has no deleterious effect on the heart. It is indicated in rheumatism, pneumonia, cirrhosis of the liver, chronic bronchitis and angina pectoris.

Whitla, in his "Dictionary of Treatment" (human medicine), states that "the presence of an abnormally adhesive or tough secretion in the bronchial tubes is best met by doses of sodium iodide combined with sal volatile." Certainly, I ascribe the complete recovery of these three horses to the use of sodium iodide.

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INCIDENTS IN TRANSIT

By G. MAYALL, M.R.C.V.S.
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THE care of animals in transport has always exercised the minds of those having their welfare at heart and has been a matter of interest and even concern to many of those employed in animal traffic. When one considers the different interests involved in the matter, it is no wonder that each individual or company that may be affected is inclined to try to look after the end of the stick as it touches them. One may discern a buyer, a seller, a farmer, a butcher, a cattle dealer, and a transit operator, all taking a part in the movement of animals by road, rail or sea.

Having spent a lifetime in connection with this business of animal transport, and having witnessed all sorts of incidents arising therefrom, I thought it might be of interest to record some of them.

In my early days many cattle were brought from Ireland to Fishguard by sea and then transported across Wales and England by rail to the great open air cattle market in Norwich. It will be seen that room for accident might occur before or during loading in Ireland, on the sea, in disembarking, and in travelling to Norwich and in unloading at the destination. Not a few of these Irish cattle were lively active beasts and not too amenable to discipline and temporary restraint. Nevertheless, it was wonderful and a credit to all concerned how few of them suffered from serious accidents in transit.

Now and then we found one with a broken leg, occasionally a dead one down and trampled on, and sometimes a diseased one that had found its way into the batch and had been unable to stand the journey.

There was a nice bit of greensward at Norwich where the cattle were unloaded and I often thought it was worth its weight in gold to the railway company.

One of the most difficult conclusions to arrive at when a bullock refused to rise from the truck was to find out whether it was injured or simply exhausted by the journey. When pulled out on to the grass, if there was any doubt, it was left there for a time, and after a reasonable interval not a few of them got up and were able to walk away.

In any estimation of damage or depreciation to a beast one had to be able to assess the market value of the animal in health and reckon the amount of loss incurred in transit. In some cases there was a mix-up about liability. Both seller and buyer might have insured an animal against accident on the journey, and on top of this an animal might have been obviously diseased when dispatched to the buyer, generally due to metritis, now and then to

tuberculosis, and sometimes to vaginitis. The seller would assert that there was nothing wrong with the animal when sold and would try to claim off the insurance company and, if unsuccessful, would claim against the buyer asserting that the animal was sound when sold. The buyer, rather than go to law, and not having received his purchase, would also try to claim against his insurance company. In such a case the value of a veterinary examination and a post-mortem cannot be overestimated.

The size of the animals comparing one with another travelling in the same truck is important. It is risky and unwise to truck big dairy shorthorns and small Jerseys together, and worse if any of the animals be pregnant. We once saw a case of this description which resulted in the death of several of the Jerseys and abortion of others. In the case of suspected injury to a beast down in the truck, it is always wise to have it turned over to the opposite side on which it has been lying and examine the limbs and ribs carefully.

Pigs are not bad animals to transport. They often get many scratches, and now and then a broken leg.

In case of a *pig* down in the truck and unable to rise, where one suspects a broken back it is always advisable to have a post-mortem as the spine may be diseased with tuberculosis. Suffocation is a calamity that sometimes happens to pigs.

Sheep are rather tricky animals for transport. They must not be overcrowded and some of the breeds jump about in the truck and are easily frightened. Here again a diseased sheep may get into the batch and should be detected. Long woolled sheep sometimes suffer from the wool being trodden on by their companions, and then some weary sights of flayed bodies may be seen, but the avoidance of such mishaps seems to be impossible when one considers the nature of the animals being transported and the previous free life they have had.

Anthrax has always to be borne in mind when an animal is found dead in a truck.

Some *horses* of a placid nature travel quite safely and comfortably in horse-boxes or road vans. Others are restive and alarmed both when loading up and on the journey. We had two cases in a fortnight where, in loading up, horses banged their polls against the sharp edge of the iron reinforcing the top of the entrance to the box. In one case the horse died from a depressed fracture of the skull, and in the other trephining relieved the pressure and the horse recovered.

A broken halter or head stall, a too long halter, may cause accidents to the horse. A kicker may damage itself badly. An influenzal horse is now and then transported and may be lame through injury or disease.

Some men assert that complete freedom in a box is a safeguard against accident, but this only applies in the case of a quite phlegmatic horse and provided there is no rough shunting.

Abstracts

A DIETARY DISTURBANCE IN SWINE

By H. J. CONRAD, K.S.C.

Veterinary Medicine, July, 1939

NOVEMBER 23, 1938, a friend and myself were called to investigate a disease in some sick pigs at Carthage, Missouri. We found on our arrival a lot of six pigs, three months of age, confined in a crowded pen. One had died and two others were sick. A number of larger hogs, on free range, were apparently in good health.

The diet of the pen pigs consisted of wheat shorts, garbage slop, and tankage, in approximately equal parts. The pigs had started getting sick three days after tankage was added to the diet.

The sick animals showed a depressed appetite and difficult breathing. The temperature was 100.5 deg. F. Hemorrhagic, edematous swellings were noticed about the head. The most prominent symptom was the presence of blush-red hemorrhagic areas, about the size of a silver dollar and of irregular shape, in the subcutaneous tissue.

Autopsies were performed on the animal which was dead when we arrived and on one that died a short time later. Extensive subcutaneous and subserous hemorrhages were present, with additional submucous hemorrhages in the mouth, pharynx and larynx, while the gums showed hemorrhages and ulcers. The bladder was entirely hemorrhagic, being filled with a large blood clot. The kidneys and liver were apparently normal.

From the diet, symptoms, and lesions, a diagnosis of protein poisoning was made. The owner was advised to remove tankage from the diet. Following this, no further cases developed and the remaining animal, which had shown symptoms of the disease, made an uneventful recovery.

THE SEROBORTAN VACCINE OF OPPERMANN-CURTIUS AND THE AO_3 PROCESS OF DR. BERTRAM, SOEST, AGAINST ABORTUS BANG INFECTION OF CATTLE *

By H. ZELLER and F. HENNINGER

THE injection of cows against infectious abortion with living organisms was forbidden by an order of the Prussian Minister of the Interior on October 7, 1936. This inoculation had been extensively carried out in Germany up to then, but failed to limit the cases of the disease.

Blood and milk examinations under present methods of husbandry were of little or no avail in eliminating the scourge.

The German Ministry of Health therefore in recent years has used two procedures which it was thought would have had an undoubted effect on the incidence of Abortus Bang infection of cattle—these are Serobortan Vaccine Oppermann-Curtius and the AO_3 process of Dr. Bertram, of Soest.

Serobortan Vaccine Process of O.-C.

Dr. Hans Curtius, the Principal of the Pharmaceutical and Serum Institute in Constanz, at the request of the Ministry has evolved and carried out a method of treatment against Bang infection with a view to eliminating the invader from the animal body and bringing about recovery. The method is by a specific vaccine. This is brought about by the simultaneous use of chemotherapy, unspecific albumen therapy and the specific inoculation material of Bang infection. Through combination of the preparation Serobortan (albumen with the addition of mineral substance) with specific vaccine he hoped to succeed in removing the invader from the animal organism and bringing about recovery.

Prof. Oppermann, of Hanover, was asked to collaborate with Dr. Curtius as he has for a long time been interested in the serobortan procedure and has published several pamphlets on the matter. O's theory is that during the last 30 years the productive capacity of cattle has been overstrained with regard to calves and milk by both qualitative and quantitative high feeding brought

* Reprint from *Zeitschrift f. Infections K. & paras. K. und Hygiene der H.*, 1939, Vol. 54, Section 4, p. 265.

about by intensive manuring. This has led to a strong addition to the mineral and albumen content of the body and resulted in an increase of fat and milk without any but little consideration being given to the question of the resistant ability of the body to disease. It has also occasioned the production of unphysiological plasma and thus led to the formation of insufficient antibodies. This has increased the pathogenity of the invading organisms and lessened the power of the defenders (the cells and tissues of the system).

In a number of the animals examined which were Bang positive he found the albumen content of the blood within normal limits, but a remarkable increase in the globulin content. Besides he found a number of cows with a low phosphorus constituent in the blood, although the blood picture seemed normal. From this unphysiological condition of the blood plasma (destructive of albumen and mineral metabolism) Oppermann deduces a weakening of the constitution and as a result a heightened readiness to infection. This latter must be remedied and Oppermann, with his serobortan treatment, seeks to restore to normal the albumen globulin quotient of the blood and the faulty state of the blood in Bang-infected animals. The Bang titre sinks, the resistance of the animal body is increased, hand-in-hand the pathogenity of the invader diminishes and therewith the number of the aborters in the herd is reduced.

The serobortan is prepared at the Pharmaceutical and Serum Institute of Dr. Curtius in Konstanz. It is prepared from the serum of healthy horses with the help of the so-called "inihibited enzyme process." The serobortan obtained (called New Serobortan) may be given orally or subcutaneously. The disturbed albumen and mineral catoptric is adjusted and as an unspecific albumen an irritative effect on the body is produced. Oppermann's idea is as follows: the bacterium abortus Bang acts in the body as an antigen and induces the formation of antibodies. Since the Bang bacterium gives out no marked toxic-inducing products the antibodies in Bang-infected animals only advance very slowly. Here and now the serobortan interposes its support; it sensitises the defensive organs of the body so that during or after serobortan treatment the Bang bacteria have then to react with a stronger defensive force. In serious outbreaks with open discharge of the bacteria the positive reacting animals should be isolated in a byre. In mild outbreaks all the animals will not take up the Bang organisms and are not immunisable and are accessible to a later infection. This failure may therefore be avoided if one shortly before or after the conclusion of serobortan treatment injects an abortus vaccine which in the sensibilised body exerts a better effect and leads to the production of an adequate immunity.

The kind of vaccine (abortin, yatren-vaccine, iodoxylan, D-vaccine, etc.) is immaterial. This combined serobortan-vaccine treatment is recommended by Oppermann and he believes that the procedure will bring about a substantial diminution of this great scourge.

The Prussian Minister of the Interior requested Oppermann and Curtius to test their findings out in the field and several affected animals in the near and distant surroundings of Berlin were bought for the trials.

Plan of Test.—After previous disinfection of the skin at the site of inoculation the vaccine was subsequently injected subcutaneously in the neck as follows:

1. Serobortan dose, 20.0 c.cm.
2. Serobortan dose, 30.0 c.cm., 14 days later.
3. Serobortan dose, 50.0 c.cm., 14 days later.

At the same time with the three serobortan doses:

10 c.cm. of D-vaccine was injected.

20 c.cm. of D-vaccine, 14 days later.

30 c.cm. of D-vaccine, 14 days later.

Shortly after the last injection a stall disinfection was carried out.

In the above way half of the test cows were treated.

The other half were treated in the same way, but in place of D-vaccine, yatren vaccine was used.

A close and exhaustive investigation of results from November, 1936, to July, 1937, on ten tested cows and three controls showed that serobortan treatment in Bang-infected cows was negative as regards causing the disappearance of Bang bacteria from the blood and milk serum.

The Prussian Minister gave further permission for tests with the vaccine intravenously and intramuscularly on nine cows.

Results examined closely from September, 1937, to March, 1938, were negative against contagious abortion.

On December 9, 1936, after favourable reports from German doctors on the use of AO_1 in human medicine, the Minister of the Interior gave permission to Dr. Bertram, of Soest, to try out AO_1 in allied affections of cattle.

AO_1 is a rather complicated hypertonic solution which has a hydræmic effect on the blood and produces its result by osmosis. It has a lower salt content than that of the blood and produces hydræmia and increases a flush of water through the kidneys and intestines. From the observations of Dr. Bertram on the womb and fœtal envelopes of affected cattle it was deemed advisable that urea should be added to AO_1 and his solution was called AO_3. It is injected in large amount intravenously or intraabdominally. The dose given to cattle was 30 c.cm. and five cows were experimented on.

The results were negative, but the Report concludes with: "It remains to be determined whether serobortan vaccine and the AO_3 procedure are efficient under practical conditions to exercise a favourable influence on contagious abortion and its sequelæ."

Further experimentation and research were seriously curtailed and interrupted by severe outbreaks of foot-and-mouth disease.

News

THE UNIVERSITY OF LIVERPOOL EXAMINATION LIST

December, 1939.—*School of Veterinary Science, Degree of B.V.Sc., Final Examination, Part I*: G. H. Arthur, Mary Dalby,* D. G. Hanbury, D. O. Sutton; *Part II*: G. H. Arthur, Mary Dalby, D. G. Hanbury, D. O. Sutton. *Fourth Examination*: J. F. Donnelly, G. D. Shaw. *Third Examination, Part I*: J. W. Barber-Lomax, B. R. Bee, H. A. Clay, P. D. L. Coates, C. M. Edwards, J. L. Foster, T. E. Gibson, C. D. Hopkins, D. K. Jones, A. H. Mahmoud, W. Pickin, I. G. Shaw, A. B. O. Stabler, A. A. Wilson; *Part II*: J. W. Barber-Lomax; *Part III*: J. W. Barber-Lomax, C. D. Hopkins, I. S. McLaren, I. G. Shaw, A. B. O. Stabler. *Second Examination*: J. F. Bolton, T. Boundy, A. Carlyle,† R. S. Dugdill, R. B. Griffiths, P. R. Hargreaves, E. B. Jones, J. Jones, W. M. Jones, Sylvia C. Jubb, P. A. Kerr, Mary McCreanor, I. S. McLennan, R. A. Richards, B. Rimmer, K. Unsworth, M. Wynne.

* Distinction in Veterinary Medicine.

† Distinction in Physiology (including Histology) and Biochemistry.

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